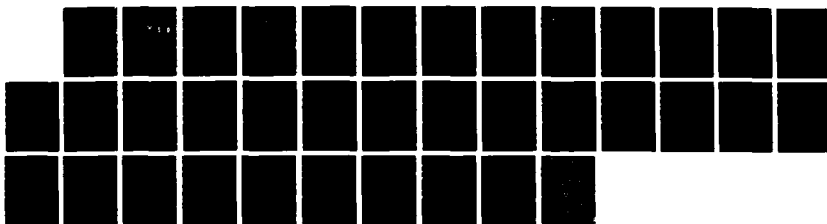AD-A194 056   USE OF A COMPUTER-ASSISTED IDENTIFICATION SYSTEM IN THE   1/1
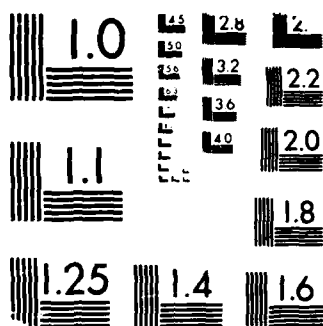   IDENTIFICATION OF..(U) AIR COMMAND AND STAFF COLL
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USE OF A COMPUTER-ASSISTED IDENTI-
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TION OF THE REMAINS OF DECEASED
USAF PERSONNEL

MAJOR GARY M. TRIPLETT   88-2610

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REPORT NUMBER 88-2610

TITLE USE OF A COMPUTER-ASSISTED IDENTIFICATION SYSTEM IN THE IDENTIFICATION OF THE REMAINS OF DECEASED USAF PERSONNEL

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Submitted to the faculty in partial fulfillment of
requirements for graduation.

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The USAF has encountered difficulty in the positive, scientific identification of deceased USAF personnel. Problems of non-availability of data and in the manual processing of data from fingerprint, footprint, and dental comparisons hinders the use of these legally and scientifically accepted methods of remains identification. Civilian agencies have developed and are using highly reliable and efficient computer-assisted identification systems to reduce these problems. The DOD has used computer-assisted identification systems successfully. The use of an integrated computer-assisted identification system by the USAF using a relational data base composed of fingerprint, footprint (for flying personnel), dental, and personal descriptor data can be developed using currently available information, technology, and computer hardware. The study briefly discusses each of these areas and advocates the development of a USAF computer-assisted identification system.

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The use of computer-assisted identification systems to provide the positive, timely, and scientific identification of remains of deceased persons is of great value to the USAF. Such systems can and have helped the USAF fulfill its requirement to identify the remains of personnel who die while on active duty. These systems have established the foundation and shown the need for the development of a computer-assisted identification system within the USAF.

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ABOUT THE AUTHOR

Major Gary M. Triplett has been a Special Agent with the Air Force Office of Special Investigations (AFOSI) since 1973. As an AFOSI Special Agent and former Regional Forensic Science Consultant for AFOSI, he has investigated and provided forensic science guidance in the investigation of numerous deaths of active duty USAF personnel and dependents. He completed a Masters of Science degree in Forensic Sciences at the George Washington University, Washington D.C. in 1978. He also completed a Fellowship in Forensic Medicine at the Armed Forces Institute of Pathology (AFIP), Walter Reed Army Medical Center the same year. In 1987 he completed a Master of Arts degree in Computer Resource Management. Major Triplett also graduated from AFIP's Forensic Odontology Course and received instruction in forensic anthropology at the Smithsonian Museum, Washington, D.C.

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EXECUTIVE SUMMARY

REPORT NUMBER 83-2610

AUTHOR(S) MAJOR GARY M. TRIPLETT, USAF

TITLE USE OF A COMPUTER-ASSISTED IDENTIFICATION SYSTEM IN THE IDENTIFICATION OF THE REMAINS OF DECEASED USAF MEMBERS

I. Purpose: To advocate the development and use of a computer-assisted identification system to assist in the positive, scientific and timely identification of the remains of deceased active duty USAF personnel.

II. Problem: Although the USAF has a requirement to scientifically and positively identify the remains of USAF personnel killed on active duty in a timely manner, a number of factors often prohibit or hinder the USAF's efforts to do so. Recent questionable remains identifications and the failure in a number of incidents to scientifically identify remains necessitate the development of a rapid and highly reliable system to assist in remains identification.

III. Data: Regulations and law require that the remains of deceased personnel be positively identified prior to the completion of a death certificate. Identification specialists maintain that the use of fingerprints, footprints, and dental comparisons are the most reliable methods of remains identification. These methods of identification are also legally accepted. The USAF and the USA Central Identification Labora-

tory currently use fingerprints, footprints, and dental comparisons in remains identification. Aircraft crashes often cause fragmentation and extensive trauma to remains and, in the cases where there are more than one victim, commingling of body parts. In these and other cases where the remains are exposed to adverse environmental conditions or otherwise traumatized the remains identification process can be very difficult. Because of the extensive amount of data and complexity of identification procedures in such cases, computer-assisted identification systems have been developed to assist the identification specialists. The US military and numerous civilian law enforcement agencies have used automated fingerprint identification systems and automated systems using dental information to quickly, scientifically, and positively identify remains. Highly reliable automated fingerprint identification systems are commercially available. The US Army is currently testing the Computer-Assisted Postmortem Identification (CAPMI) System it developed to assist in remains identification. CAPMI uses dental information collected during routine, periodic dental examinations as a data base in remains identification by means of dental comparisons. Some civilian law enforcement agencies are very successfully using computer-assisted identification systems which use integrated relational data bases composed of fingerprint, dental, and personal descriptor information (physical characteristics, medical anomalies, etc.) in remains identification. The USAF currently collects all the dental, fingerprint, footprint (in the case of flying personnel), and individual descriptor information on all active duty USAF personnel necessary to establish relational data bases to be used for remains identification. The development of a computer-assisted identification system using such data bases would greatly enhance the USAF's ability to positively and scientifically identify the remains of deceased active duty USAF personnel in a timely manner. No computer-assisted identification system is currently available for USAF use.

IV. Conclusions: The USAF often experiences great difficulty in positively identifying the remains of USAF personnel killed on active duty. Computer-assisted identification systems have been/are being developed to manage the vast amount of data associated with the identification of remains by means of fingerprints and/or dental comparisons. The USAF possesses or routinely collects the personnel identification data necessary to develop very comprehensive personnel identification computer data bases which would include all active duty USAF personnel. The technology and hardware for development of a highly automated computer system to use these relational data bases currently exists and is available. Such a computer-assisted identification system would improve the USAF's ability to positively and scientifically identify the remains of deceased personnel in a timely manner.

V. Recommendations: The USAF must take action to insure all USAF personnel who die while on active duty are positively and scientifically identified. The USAF should immediately initiate action to acquire a computer-assisted identification system which would use fingerprint, footprint (for flying personnel), dental, and personal descriptor information in relational data bases to assist in the identification of the remains of deceased active duty USAF personnel. The system should be centrally located and accessible via electronic communication means to USAF installations worldwide. The personnel identification data on all active duty USAF personnel necessary for the system should be entered into the system and updated periodically as required by data changes.

Chapter One

INTRODUCTION

The positive, scientific identification of its dead in a timely manner is a requirement for the United States Air Force (USAF), but one which is not always fulfilled. The use of computer-assisted identification systems can help resolve this problem. This paper will discuss the basis and reasons for the requirement to identify military remains and some of the difficulties which hinder its accomplishment. Fingerprint, footprint, and dental comparisons, legally and scientifically accepted methods to identify the remains of even extremely traumatized deceased individuals, are briefly discussed along with some of the problems encountered in their use. Computer-assisted identification systems which have been developed and used to help reduce the problems involved in scientific identification of remains using these identification methods are presented in a summary manner. Finally, the potential application of a computer-assisted identification system for the positive, scientific, and timely identification of deceased active duty USAF personnel is addressed.

This paper does not address economic or other costs associated with the development or use of a computer-assisted identification system by the USAF. Nor is a specific system design proposed. Rather, the intent of this paper is to illustrate the need for a computer-assisted identification system in the USAF and the feasibility of design and implementation of such a system using current technology and data readily available to the USAF.

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Chapter Two

REQUIREMENT FOR THE TIMELY, POSITIVE, AND SCIENTIFIC IDENTIFICATION OF REMAINS OF DECEASED ACTIVE DUTY USAF PERSONNEL

The positive and timely identification of the remains of deceased active duty USAF personnel is required by regulation, policy, and law. AFR 143-1, Mortuary Affairs, Section C, Identification of Remains, Paragraph 8-10, Policy on Identification, states "It is the policy of the Air Force to individually identify remains of deceased personnel, when possible, and to use all available means and scientific resources to accomplish this." Further, the US Army Central Identification Laboratory (CIL), which has the mission of identifying the remains of Department of Defense (DOD) personnel submitted to it for identification by all DOD branches, is required by Army regulation and guidance to positively identify by scientific means such remains. (26:2-15) In addition, in all deaths a death certificate for each set of remains must be completed prior to burial. A death certificate cannot be completed until remains are positively identified. (28:6-2) By law, verification of a member's death must be accomplished via a death certificate for settlement of the deceased member's estate, award of benefits to his/her dependents, or the re-marriage of his/her spouse. (4:655) The positive identification of the deceased must also be accomplished as quickly as possible to permit official notification of the next of kin. (28:6-2) Many times the next of kin challenges the remains identification as is their right by law. (37:--) Thus the USAF has the responsibility to positively and scientifically identify the remains of personnel killed while on active duty and to do so as quickly as possible.

Chapter Three

SCIENTIFIC METHODS OF POSITIVE REMAINS IDENTIFICATION
APPLICABLE TO DECEASED USAF PERSONNEL

Scientific means are available and are used to accurately and positively identify the remains of deceased individuals. While many deceased active duty USAF personnel are identified based upon the personal recognition of the remains by someone who knew the deceased or by objects found on the remains (dog tags, identification cards, etc.), these methods of identification are not considered accurate nor reliable by remains identification specialists. (3:39) These methods of identification are totally unsuitable when the remains are decomposed and/or highly traumatized. Personal effects found on or near the person of or, as is occasionally the case in aircraft crashes, in the body cavities of deceased individuals, are not generally sufficient evidence for the identification of the remains. These items may, intentionally or unintentionally, be placed with the wrong remains during recovery procedures or perhaps even before the crash. Based upon the need to positively identify remains a variety of highly accurate and reliable scientific means of individual identification have been developed. The two most frequently used of these scientific means of identification are friction ridge patterns of the human skin present on the fingers/thumbs and feet (fingerprints and footprints) and anomalies of the human dentition. Fingerprints have been considered the most reliable, accurate, and applicable means of personal identification since the early 1900's. Individual identification using fingerprints and footprints is based upon the scientifically established uniqueness of the ridge patterns present on the skin's surface of each individual's fingers/ thumbs and feet. (3:39) Though the most widely accepted means of individual identification, the use of fingerprints and/or footprints is often not applicable for the identification of deceased personnel. Because of the condition of the remains as a result of fire, fragmentation or dismemberment due to trauma, or adverse environmental conditions, useable fingerprints or footprints cannot always be obtained from the remains of deceased active duty USAF personnel. In such cases the identification of remains by dental records is the method of choice. Identification based upon comparison of antemortem (before death) dental records and postmortem (after death) charting of the dentition of recovered remains is considered second only to fingerprints as a scientifically reliable means for the identification of deceased personnel. (4:655) Dental identification

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is particularly useful in identifying air crash victims whose remains are generally severely traumatized, burned, or otherwise damaged. This is due to the extreme durability of dentition. (3:254) "The most reliable method of positive identification of a skeletonized victim is through the use of dental records." (2:113) This is particularly important for military personnel whose remains may not be recovered for years following an armed conflict such as the war in Vietnam from which the remains of United States military personnel are still being recovered. With the individuality of fingerprints, footprints, and the human dentition established in the scientific community, fingerprints, footprints, and dental comparison are considered the best and most applicable methods of scientific remains identification. (19:252) These methods of identification are accepted in most jurisdictions and used in conjunction are the means generally used in the identification of remains in mass disaster incidents. (31:4)

The DOD has recognized the applicability of fingerprints, footprints, and dental comparison for the scientific identification of deceased active duty personnel for some time. In 1959, the USAF began footprinting of all aircrew members. The footprints are to be used for remains identification to supplement the fingerprints obtained from all active duty personnel when they enter service. (10:4) The footprints of USAF personnel performing flight duty recorded as a permanent part of the member's medical record on AF Fm 137, Footprint Record, are reviewed for accuracy and currency during each flight physical. (30:2-1) The fingerprints of all active duty USAF personnel are recorded on FD 258, FBI Applicant Fingerprint Card, upon entry into the USAF and are maintained in a Federal Bureau of Investigation (FBI) repository. These records are also periodically updated during security clearance updates. (29: 2-22) The potential use of dental comparisons for remains identification is of particular importance to the DOD because of the often traumatized or skeletonized state of military remains. Comprehensive dental examinations are a part of the routine initial inprocessing of all USAF members and their official dental records are established at that time. Each active duty USAF member's dental records are updated during their required annual dental examinations. (30:2-1) In 1962 the Armed Forces Institute of Pathology (AFIP) conducted the first DOD course in forensic dentistry. The purpose of the course was to consolidate knowledge and techniques of individual identification using dentition comparison. (22:37) This course is still taught periodically at AFIP. The United States Army (USA) requires that all remains submitted to the CIL for identification be fully fingerprinted (when the condition of the remains permits), footprinted, if suspected to be the remains of a member of the Air Force and the condition of the remains permit, and a complete dental charting of the remains be accomplished. (26: 2-15) The basic data necessary for the use of fingerprints, footprints (in the case of flying personnel), and

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dental comparisons to be used to scientifically and positively identify the remains of all deceased active duty personnel is thus generally available to the USAF and is currently used in the identification of deceased active duty USAF personnel.

Chapter Four

CURRENT PROBLEMS IN IDENTIFICATION OF REMAINS
OF DECEASED USAF PERSONNEL

The positive and timely identification of remains can be very difficult due to the condition of the remains and/or the number of remains being processed. In aircraft crashes where the remains of the deceased are exposed to high speed impact trauma, fire or explosion, and/or commingled with other remains the remains are generally difficult to identify. Skeletonized, decomposed, or burned remains or remains subjected to adverse environmental conditions are similarly difficult to identify. When large numbers of victims are involved in an air disaster the trauma suffered by the victims and the commingling of body parts often makes the individual, positive identification of each victim a lengthy and complex process. In the November 1985 Gander, Newfoundland crash of an aircraft chartered by military personnel, all 256 personnel on board the aircraft were killed. 248 of these victims were active duty military personnel. Based on historical experience, optimistic estimates of identification specialists were that approximately only 70% of the remains would ever be positively identified by means of fingerprints and/or dental comparisons (no footprint records for these individuals were maintained) due to the trauma suffered by the remains. (9:18) Even when remains are recovered reasonably intact other conditions may impact on the remains identification process. The author was involved in the identification of the remains of a number of USAF personnel killed in the crash of a Spanish Air Force C-130 aircraft near Zaragoza, Spain in the early 1980's. While there fortunately was no fire associated with the crash, the difficult task of identifying the commingled and highly traumatized remains was complicated by the international nature of the incident. This necessitated immediate identification of the deceased personnel. Special arrangements to obtain medical and dental records of the US personnel believed on board had to be made in order for the identification of these remains to be accomplished. The hazardous conditions to which USAF personnel, particularly flying personnel, are routinely subjected may result in deaths in which the recovered remains are very difficult to identify. In jet aircraft crashes very little of the pilot's and/or crew's remains are generally recovered. (37:--) Remains identification can therefore be particularly difficult for USAF personnel. The USAF has been aware of the need for and difficulty in the positive, scientific identification of its person-

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nel for some time and is committed to doing everything possible to promptly and positively identify deceased USAF personnel. (11:264)

Despite concerted efforts the DOD's procedures for the identification of deceased personnel has been the subject of professional and public criticism. A former CIL employee has publicly alleged that a large percentage of the identifications made by the CIL are incorrect. (25:12) Some experts in the field of remains identification agree with this former CIL employee. As an example, they maintain the CIL identification techniques used in the 1985 identification of 13 crewmen of an AC-130 gunship which crashed near Pakse, Loas in December, 1972 were unscientific and unprofessional. (25:12) An independent DOD panel confirmed that some remains identification techniques used by the CIL in that incident were unscientific and not in accordance with CIL policies and regulations. The CIL's questioned techniques of remains identification centered upon the use of records, personal possessions recovered with incomplete, skeletonized and commingled remains, and unscientific assumptions in the identification of the remains. (24:2) Such incidents illustrate the need for the use of highly reliable and accurate methods of remains identification in every instance.

In incidents not involving the crash of military aircraft, questionable techniques are also used in the identification of deceased USAF personnel even when their remains are recovered relatively intact. In many cases of homicide, suicide, and accidental death in which the author has been involved, deceased USAF personnel were identified based only upon personal recognition of the remains by some one who knew the deceased, comparison with identification card or other photographs, or based upon items found on the person of the deceased. All of which are highly unreliable and unscientific means of remains identification. (3:39) Such unscientific means of remains identification are generally used when the remains are autopsied or processed by other than DOD authorities and/or when the use of scientific means for positive identification would result in what is considered by the uninformed as an unreasonable delay in processing the remains. In cases where the death certificate is executed and the remains are then released for burial or other terminal processing by non-DOD authorities, the USAF is often prevented from insuring the remains are scientifically and positively identified. It is the general practice of the author and other Air Force Office of Special Investigations Special Agents to attend, whenever possible, the autopsies of all deceased active duty USAF personnel and obtain fingerprints of the deceased's remains for identification purposes. Unfortunately, these fingerprints are generally filed away only to be used should the identification of the remains later be questioned. In many cases there is no opportunity to fingerprint the remains. Therefore, no scientific identification of the remains ever takes place in many cases. In those

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cases where dental comparisons are used to identify the remains, appropriate identification procedures are not always used. Appropriate dental identification procedures require that the dentition of all of the remains recovered in an incident be charted and then the postmortem chartings individually compared to all the antemortem dental records of suspected victims. Potential matches are then made and confirmed by at least two dental identification experts. On occasion, particularly when one or small numbers of remains are recovered in an incident, antemortem dental records of the suspected victim(s) is (are) directly compared with the dentition of the remains. No actual charting of the remains' dentition is accomplished and often only one dentist, who may or may not be trained in dental identification, is involved. This may lead to questionable identifications which have no way, aside from the dental examiner's memory, to rebut challenges to the identification. Such dental comparison procedures are unsatisfactory to dental identification experts. (31:--) In many cases the efforts to appropriately use dental identification procedures are thwarted by incomplete or lost dental records. In a recent case the skeletal remains of a suspected airman were recovered. The airman had been missing in a wilderness area and unaccounted for since 1978. The skeletal remains were intact thus presenting an excellent opportunity for quick and scientific, positive identification of the remains by dental comparisons. Unfortunately the dental records of the missing airman could not be located. The remains were finally identified almost a year later after an extensive and expensive identification investigation was completed. What could have been a relatively quick remains identification became a highly complex one due to the loss of the member's dental records. USAF remains identification experts state that the non-availability of dental and fingerprint records for USAF personnel is not uncommon. (37:--) The USAF has thus encountered numerous incidents when unreliable and unscientific means of identification have been used to identify deceased active duty USAF personnel.

Chapter Five

USE OF COMPUTER-ASSISTED IDENTIFICATION SYSTEMS
IN REMAINS IDENTIFICATION AND THEIR MILITARY APPLICATIONS

The primary reasons for use of unscientific techniques for the identification of remains of deceased DOD personnel have been the non-availability of fingerprint and dental records and the length of time necessary to compare antemortem fingerprint and dental records of suspected victims with postmortem fingerprinting and/or dental charting of recovered remains or remains' parts. The FBI has the fingerprint records of millions of individuals in its files and receives some 27,000 fingerprint cards for comparisons daily from over 20,000 active users of its Identification Division. (18:2,8) At present the only repository for the fingerprints of active duty military personnel is the FBI Identification Division. Currently requests for fingerprint comparisons of deceased USAF personnel must be forwarded to FBI headquarters in Washington, D.C via mail. The fingerprints of suspected victims on file are manually compared by fingerprint experts with the mailed fingerprints obtained from recovered remains. This is often a very lengthy and time consuming process. Unfortunately FBI fingerprint repositories cannot always be relied upon to locate fingerprint records for active duty USAF or other military personnel. The FBI's fingerprint files for military personnel have been found to be incomplete in some cases. Many times the new fingerprint cards completed during periodic security clearance updates are discarded once the security investigation is completed. Since the military services keep no independent fingerprint files, there are no fingerprint records available for use in the remains identification process in such cases. (37:--)

The availability of the dental records of deceased DOD personnel becomes a problem when the death occurs away from the member's permanent base of assignment where his/her dental records are maintained or when the records are lost or destroyed in the incident which caused the member's death. In the October 1983 bombing of the Marine headquarters in Beirut the medical and dental records of the Marines assigned were destroyed as they were maintained in the building bombed. This greatly complicated the identification of the remains as at that time no copies of a DOD member's medical or dental records were maintained anywhere. (20:19) Non-availability of fingerprint, footprint, and dental data and data processing problems at least partially explain, but do not excuse, the identifications

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of deceased USAF active duty personnel by other than scientific means.

Computer-assisted identification systems can provide ready access to data for personal identification and serve as a back-up for original personal identification data. The use of automated data processing is common place in the United States and is widely used by the DOD. The general procedure in any automated data processing operation is to use some source document to establish a computer file for data storage and processing. Any well designed automated data processing system has a periodic file up-date and back-up file creation procedure as part of its operation. A computer-assisted identification system uses some source document (fingerprint card, footprint form, dental chart, etc.) to create a computer file. This computer file is periodically updated and back-up copies of the files are maintained. Thus the data to be used in the identification of remains is stored in a format suitable for automatic data processing and the system provides a back-up record for the original source document. A program using the data stored in these computer files and comparing it with data input obtained from recovered, unidentified remains can be used to assist the identification specialist in identifying the remains. The use of the computer for automatic data processing can greatly reduce the time required for comparing antemortem and postmortem data.

Historically one of the major obstacles in the use of fingerprints for individual identification has been the time and effort required to compare fingerprints or partial fingerprints of varying quality with the fingerprints on file of possible victims. This task is often difficult even when there is only one victim as may be the case in the crash of a single seat fighter aircraft whose pilot was at least tentatively known. A crash in which the pilot did not eject generally involves extensive trauma to the pilot's remains due to high speed impact often accompanied by fire and/or explosion. In such cases, very little remain's tissue material is generally recovered and that which is recovered is generally in very poor condition. Rarely are all ten digits of the deceased's hands recovered intact. The tissue damage on recovered digits may further reduce the amount of useful fingerprint data suitable for identification purposes. This was one of the USAF's primary reasons for footprinting flying personnel. While flight boots can reduce the trauma and tissue damage to the deceased's feet, such is not always the case and such relatively large remain's parts as intact feet are not always recovered. Thus sufficient fingerprint/footprint data cannot always be obtained to make a positive identification. These factors often create major problems in remains identification when there are a number of victims and there is commingling of remains. A computer-assisted identification system has proven to be of significant benefit in helping to manage the fingerprint/footprint

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data obtained from recovered remains in such cases and that available from record repositories.

The concept of using computers and automated data processing in the identification of individuals has lead to the development of increasing more sophisticated and capable computer-assisted identification systems based upon fingerprints. As early as 1934, one year after it was established, the FBI Identification Division recognized the need for computer-assisted automation in the processing of fingerprint identifications. Unable to develop a suitable system on its own, the FBI requested assistance from the National Bureau of Standards (NBS). NBS assistance resulted in development of the Latent Descriptor Index System which used computer punch cards to locate fingerprints with a certain classification code. This system required manual input of data concerning the questioned fingerprint(s) and manual comparison of all the fingerprints selected as possible matches from the data base. While helpful, it was grossly inefficient. A major advancement in computer-assisted identification systems was made when methods for automated fingerprint data comparison were developed. These methods use computer logic through algorithms to match fingerprint data obtained from the unknown print with coded fingerprints on file in a data base. These advancements resulted in development of the Automated Latent System Model (ALSM). This first generation computerized fingerprint identification system uses the positions and direction of fingerprint minutiae (fingerprint ridge endings and ridge bifucations , splitting of the ridge) to make comparisons between unidentified fingerprints and fingerprints in the established data base. With this system the system operator places the unidentified fingerprint under a camera on a computer terminal which projects the fingerprint on a cathode-ray tube (CRT) screen. The operator then marks the minutiae position and direction in the fingerprint with a cursor. An algorithm converts this information into mathematical form. The information is then entered into the computer memory. The operator performs this function for each minutiae present in the unidentified fingerprint. The computer then compares this information with the minutiae information of known fingerprints in its data base. A list of possible matches based on minutiae statistical correlation is produced in descending order of match probability. A fingerprint expert then compares the unidentified fingerprint with the fingerprints of the ordered lists. (18:2-8) This highly successful automated fingerprint identification system was further improved with an automatic fingerprint reader which removes the need for the operator to manually mark each minutiae in the fingerprint as the fingerprint reader does it automatically. This system is commercially available as the Printrak Automated Fingerprint Identification System (AFIS).

The Printrak AFIS consists of a Read/Edit Operator Console, Print Processor, Search Processor, Data Storage Subsystem, and

Printer Unit. The Read/Edit Processor serves as the interface between the computer and the operator. Its console consists of a keyboard, CRT display, automated fingerprint card indexer, video scanner, cursor control, and console electronics. The operator console operates in either an automatic fingerprint card read mode, manual fingerprint encoding mode, or manual latent fingerprint encoding mode. In the automatic fingerprint card read mode, a fingerprint card is placed on the card-index-er platform and the video images of the prints are transmitted to the Print Processor which automatically encodes the minutiae and returns a display of the print with encoded minutiae and print classification to the CRT display screen. The operator can then edit the display and change the encoded minutiae or classification if desired. The Print Processor works with the Read/Edit Operator Console to process the images received, extracting exact minutiae from the fingerprint and classifying it. The processor includes an image processor, automatic classifier, a minicomputer, disk memory, and a multiplexer. The Search Processor, which controls the flow of data into and out of the Data Storage Subsystem, contains a minutiae matcher unit which compares the encoded minutiae of search prints (those trying to be identified) with the filed minutiae from record fingerprints maintained in the Data Storage System. The minutiae matcher unit scores each match based on the closeness of the match and transmits the results to the Search Processor. The Data Storage Subsystem has the capacity of eight (8) 300-megabyte disk drives and multiple disk packs. The ten (10) print fingerprint files of up to 100,000 people can be stored on a single on-line disk pack. Unidentified latent finger-prints can also be stored for comparison with new 10-print record fingerprint cards or other latent fingerprints. The Search Processor transmits the results of the matching pro-cess to the Printer Unit which produces a printed listing of possible matches and the probability of each possible match. The Printrak Automated Fingerprint Identification System may be networked with the Printrak Latent Subsystem which is comprised of a Read/Edit Operator Console and a Printer. The subsystem allows remote on-line direct access or off-line batch process-ing of latent fingerprints and file entry and comparison of new 10-print record fingerprint cards. (33:--)

Printrak's success lead to the development of an automated fingerprint identification system by NEC Information Systems (subsidiary of Nippon Electric Company of Japan) for the Japa-nese National Police. The NEC AFIS operates much the same as the Printrak AFIS and consists of a fingerprint input subsystem and a fingerprint matching system. There are of course hard-ware differences between the NEC and Printrak systems such as NEC's use of an optical storage disk, but the data processing is very similar. One distinct difference between the two sys-tems, however, is that the NEC AFIS uses minutiae relationship (the counts of ridges between a minutiae and its neighboring minutiae) as well as the positions and direction of minutiae for

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match identifications. NEC maintains that the use of minutiae relationship in addition to minutiae position and direction increases the accuracy of identification and that the system is not affected by fingerprint distortion or deviation in fingerprint direction and position as is the case in the Printrak AFIS. In the Printrak AFIS the marked image of the search print must be rotated for minutiae comparison. This is not necessary with the NEC AFIS. The NEC AFIS, currently in use by law enforcement agencies in Tokyo, San Francisco, Sacramento, Anchorage, Alabama, and Calgary, Canada, is receiving acclaim as a result of its use in solving two police investigations in California. (6:--) (36:--) Since its purchase of the 2.6 million dollar NEC AFIS in 1984, the San Francisco Police Department (SFPD) has solved two major murder investigations directly as a result of fingerprint matches made by the system. By comparing latent fingerprints recovered from the crime scene of the murder of a San Francisco woman with SFPD fingerprint files the NEC AFIS identified a suspect who was subsequently arrested for the crime. The NEC AFIS is credited with solving this six year old murder case. (17:--) Impressive as resolution of that case was, the identification of the infamous Los Angeles Night Stalker using the NEC AFIS is the success that has brought this investigative technique to public attention. The NEC AFIS matched a fingerprint lifted from a vehicle at one of the fifteen (15) murders attributed to the Night Stalker to the file fingerprint of a drifter with a record of drug abuse and automobile theft. Two days later the suspect was arrested for the murders. The Los Angeles Police Department (LAPD) estimated it would have taken a fingerprint examiner sixty-seven (67) years to compare the latent fingerprint recovered from the crime scene to the 1.7 million fingerprints on file with the LAPD and possibly match that single fingerprint to the suspect arrested. The NEC AFIS accomplished the task in a few hours. (21:--) These are but two of the many dazzling successes of the NEC AFIS which has made the use of automated fingerprint identification systems the most important revolution in personnel identification technology in decades. (18:3)

Computer-assisted identification systems based on fingerprint comparison have proven to be highly effective and reliable. These systems are capable of comparing a single fingerprint with over 1,200 fingerprints in a data base per second. (17:--) The benefits of such a system are recognized worldwide. The British have used an automated fingerprint identification system since the mid 1970's. (13:221) There are currently twenty-two Printrak AFIS systems in use in the United States and six others are being used in foreign countries. (6:68) Unfortunately full development and implementation of the FBI's automated fingerprint identification system was halted in 1985 due to budgetary constraints. (5:22) At present the system contains only criminal record files and its use is restricted to criminal inquiries. It is not used in remains identification in non-criminal matters. (37:--) When used auto-

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mated fingerprint identification systems can greatly reduce the time intensive efforts previously required in the use of fingerprints to scientifically and positively identify human remains.

While automated fingerprint identification systems are highly useful in remains identification, computer-assisted identification systems based on dental comparisons are of even greater use in remains identification for air crash victims. As has previously been stated, the conditions of remains subjected to high speed aircraft crashes are often such that fingerprints cannot be obtained. Dental comparisons of postmortem dentition charting of the remains with antemortem records of possible victims has proven to be the best method of scientific and positive remains identification in such cases. (3:254) Computer-assisted identification systems based on dental comparisons have been developed and have proven to be of great benefit in the use of dental data for the identification of air crash victim remains.

Identification procedures using dental comparisons have been troubled with the problems of the lack of data bases, the difficulty of handling the overwhelming amount of data generated by dental comparisons, and a variety of dental charting methods. Historically when a mass disaster incident occurred, the antemortem dental records of all potential victims had to be hurriedly collected and forwarded to the remains processing location. This was often a very long and difficult task. However, the most arduous and time consuming part of the task of dental comparisons was comparing the dental chartings of the remains with the antemortem dental records collected. The adult human dentition consists of thirty-two teeth each of which has six positional references and five surfaces which are used in dental comparisons. (19:246) These factors plus all the potential restorations and other dentition alterations can produce an amount of data which is almost impossible to manually manage. Add to this the variety of different charting procedures used in dental records and the potential difficulty in the timely use of dental comparisons for remains identification becomes readily apparent.

The great potential for remains identification by dental comparisons has resulted in military efforts to overcome the problems associated with the collection and use of dental data and to develop a computer-assisted identification system based on dentition within the DOD. This potential was perhaps first recognized in 1974 when a relatively unsophisticated computer-assisted dental identification system enabled the identification of the victims of a civilian aircraft crash in approximately 30% of the time required for traditional identification procedures. (14:194) The potential for military use of such a system was emphasized by the use of a computer program by military forensic specialists in the identification of the 913 vic-

tims of the Jonestown, Guyana tragedy. Relying largely on computerized dental information, the identification time required for each set of remains from that tragedy was reduced from approximately 30 hours to a matter of minutes. (31:15-16)

Computerized comparison of antemortem and postmortem dental data greatly reduces the overwhelming amount of time and effort which can be spent during manual searches of dental records in dental identification procedures. (7:352)(12:247) In the first successful use of a computer-assisted identification system based on dental comparisons in a military related aircraft crash, Col. (Dr.) Robert R. McMeckin, USA, director of the Armed Forces Institute of Pathology used a computerized dental record comparison program to help positively identify all of the 256 victims of the 1985 Gander air crash. The victims of that aircraft crash, "the greatest tragedy in military aviation history" (9:18), included 248 active duty military personnel. The use of Dr. McMeckin's computer-assisted system was partially responsible for the scientific and positive identification of all the victims of that crash weeks ahead of schedule. (9:18) While certainly not the first time a computer had been used to assist in comparing antemortem and postmortem dental records, this application of a computer-assisted identification system brought the potential military use for such a system to the forefront.

Recent advancements in computer processing speeds and data storage methods have made such a system viable for the military. The availability of current dental records for all active duty military personnel and relatively uniform DOD dental charting and record keeping systems leaves only the basic problem of data management in the development of a military computer-assisted identification system. (14:192) The uniform DOD dentition numbering and coding system makes the handling of large amounts of data relatively easy to computerize. (31:9) These factors have lead to development of the Computer-Assisted Postmortem Identification (CAPMI) System by the United States Army.

CAPMI is a recently developed computer identification system based on dental data for use in the identification of the remains of active duty military personnel. The system uses two updated and improved algorithms which take into consideration possible data base errors. This is basically accomplished by comparing the unidentified records by maximum number of matches and by minimum number of mismatches. This allows the system to have a high degree of selectivity (ability to differentiate one record from all others) even when the data base has 10-40% errors. (15:973) The system is designed so that the data necessary for the data base is obtained during routine annual dental examinations of military personnel. The data is initially recorded on a special form and then entered into the computer's data base by means of an optical scanner. The data base is

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stored on magnetic tapes or disks. To identify a set of remains the remain's dentition is charted on the special form, entered into the computer by means of the optical scanner and then compared with the data base. A rank ordered list of possible matches is then produced. Then, as is the case with all computer-assisted identification systems, the unidentified remain's record is manually compared with the possible matches produced by the computer. A forensic dental identification specialist makes the actual identification. The computer does not make the identification.

CAPMI was initially tested in the identification of the remains of eleven service members recovered from the crash of an Air Force Reserve C-130 aircraft near Honduras on 22 January 1985. Using the CAPMI system, a computer compared the ante-mortem dental records of the military personnel with the post-mortem dental data of the twenty-one personnel on the flight. The computer made its possible matches in seven minutes. It took three forensic dentists two hours each to complete the comparisons with the same results. (20:22)

In other tests with a population group of 578 personnel composing the data base, the computer system listed the correct person as first on the list of possible matches 86% of the time. The correct match was listed as one of the other probables the remainder of the time. Preliminary evaluation of the CAPMI system is that it is a quick and efficient method of determining a subset of records for subsequent manually matching. (15:980) As the system is currently designed, it can be used on a variety of computers ranging from mini-computers to highly portable battlefield systems. (20:22)

One major advantage of such computer technology is that it helps the forensic dentist deal with dental fragments. The handling of pieces of a victim's dentition is one of the most difficult and time consuming aspects of dental identification. (31:18) It is possible to identify a victim based upon a single tooth if it has adequate individuality. (19:246) The ability to handle dental fragments in an incident in which the remains of victims are commingled and/or severely traumatized, as often happens in air crashes, is therefore of major significance.

Because of the greatly reduced processing time and increased ability to handle large amounts of data, a computer-assisted dental identification system would have great value to the military where armed conflict can result in the deaths of large numbers of military personnel. The aim of the CAPMI system once it is implemented is to have a computerized dental record for all active duty military personnel to aid in remains identification. (20:19)

Identification experts have recognized that the probability

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of quickly and positively identifying human remains in a scientific manner is significantly increased when computer-assisted identification systems based on fingerprints, dental records, and other personal descriptor information are used jointly. (7:349) In 1983, the Washington State Crime Information Center (WACIC) developed and began to use a computer-assisted identification system which used dental and fingerprint records along with other physical descriptive data of missing persons in a relational data base to help identify the recovered remains of unidentified persons. In this system possible matches with rank ordered probability scores are produced when fingerprint, dental and, when possible, other physical information obtained from examination of remains is entered. Identification specialists then use this listing to do physical comparisons of antemortem records with postmortem records to make the actual identifications. This on-line system has greatly reduced the time previously expended in manual searches of records. This system of remains identification has also proven to be highly effective and reliable. (32:--) Realizing the tremendous advantages of computer identification systems using multi-parameters, the National Crime Information Center has developed computerized Unidentified Person/Missing Person files using fingerprint, dental, and other individual information. This national system, which operates in a manner very similar to the WACIC computer-assisted identification system, is likewise proving to be a very useful method of assisting in the positive, scientific identification of unidentified human remains. (7:349-371) Computer-assisted identification systems which use fingerprint, dental, and other individual identifying data in conjunction have thus been proven to be extremely valuable in the positive, scientific identification of human remains in a timely manner.

Unfortunately the USAF has no computer-assisted identification system. The systems used by the DOD and the USAF thus far have been ad hoc ones and have been used on a very limited basis. USAF identification experts state that the use of a computer-assisted identification system would greatly improve the timeliness of the identification of deceased personnel. This would be particularly true in aircraft crashes and other instances in which the recovered remains are highly traumatized. (37:--)

Chapter Six

CONCLUSIONS

USAF personnel who die while on active duty are not always positively identified by scientific means as is required by regulation and law. The DOD's failure to use scientifically and legally accepted means of remains identification has resulted in public and official concern and criticism. The extensive trauma military remains are exposed to, particularly in high speed aircraft crashes, environmental conditions, and commingling of remains often makes their individual identification difficult. Fingerprints, footprints, and comparison of antemortem dental records with postmortem dental charting of remains are reliable and legally accepted methods of scientific remains identification which can overcome these problems. These methods of remains identification are not always used due to the non-availability of necessary records and the difficulty encountered in manually managing the vast amounts of information involved, particularly when there are large numbers of remains. Efforts to more easily manage this information have resulted in development of a number of highly effective computer-assisted identification systems. The FBI and other federal and local law enforcement agencies have used computer-assisted fingerprint identification systems such as Printrak AFIS and NEC AFIS to solve crimes in record time. The DOD has used similar systems which use dental data rather than fingerprint data in a number of instances such as the 1985 Gander air crash. As with other computer-assisted identification systems, the results have been very impressive. Tentative identifications are made in seconds rather than hours or days. Confirmative comparisons have shown these systems to be highly selective and very accurate. The recognized potential for such dentition comparison systems in the DOD has resulted in the development of the CAPMI system which is currently undergoing testing and evaluation. The effectiveness of computer-assisted identification systems has been greatly enhanced through development of systems which use integrated relational data bases composed of fingerprint data, dental data, and personal descriptor data. The WACIC and NCIC systems are excellent examples of such relational data base systems. The use of computers to assist in the identification of remains is therefore well established.

The USAF has the potential to develop a relational data base computer-assisted identification system using existing

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technology and data routinely collected on USAF personnel. Fingerprint records of all USAF personnel are obtained upon a member's entry into service. Dental records are maintained in a standardized form on each USAF member and updated annually. The footprints of personnel on flying status are obtained and kept current during annual flight physicals. Personal information on all USAF members is on file at the Air Force Military Personnel Center or in their medical records. Algorithms for computer-assisted identification systems are available as is all the hardware necessary to establish the system. Thus the development of such a system is feasible and possible with existing technology.

A USAF centralized computer-assisted identification system using the relational data bases described would provide ready access to data necessary to scientifically and positively identify deceased active duty USAF personnel. This would enable faster and more reliable remains identification than is currently possible. A spin-off benefit would be the establishment of back-up files for dental and fingerprint records for each USAF member. At present such back-up files do not exist for most personnel. If the original files are lost or destroyed, they must be reconstructed. This, unfortunately, is not always possible. The loss of records has been a major problem in the identification of deceased military personnel on several occasions. Putting such information in electronic storage form also allows for rapid data transfer almost anywhere in the world. Thus the data is very accessible to necessary users.

A USAF computer-assisted identification system would greatly reduce the current peacetime problem of remains identification. The potential value of such a system in wartime when there are large numbers of USAF personnel killed in action can only be guessed at, but undoubtedly would be immense.

Chapter Seven

RECOMMENDATIONS

The USAF should develop an integrated computer-assisted identification system using relational data bases. The data bases should consist of individual personal information, fingerprint information, dental information and, in the case of flying personnel, footprint information. The data necessary to build such data bases currently exists in USAF or other federal record systems. The Printrak AFIS, NEC AFIS, and similar systems have the capability to automatically enter data from already maintained fingerprint cards into a fingerprint data base. Likewise the CAPMI system, through the use of its optical scanner, can create a dental information data base using the standard dental examination records maintained and annually updated on all active duty USAF personnel. An extensive amount of personal information already exists in the computerized, centrally located personnel records maintained on all active duty USAF members. Algorithms and computer programs would have to be written to use footprint information from the footprints of flying personnel maintained in their medical records. However, this should not present a major obstacle given the development of similar algorithms and programs for use of fingerprint and dental information.

The integrated computer-assisted identification systems currently in use by the WACIC and the National Crime Information Center prove that such a system is feasible, cost efficient, and highly effective. Such a system, centrally located and with on-line access, would allow electronic comparison of fingerprint, footprint, dental and/or personal data obtained from examination of any number of sets of remains or remains parts. Through electronic data transfer procedures the remains could be tentatively identified in a relatively short period of time. Copies of records on file for possible matches could then be supplied via electronic means to the requestor to be used in the actual identifications. Such a system should allow for the scientific, positive identification of deceased active duty USAF personnel in a timely manner.

At the present time no complete computer-assisted identification system for the identification of deceased USAF personnel is available for USAF use. The technology and data necessary to build an integrated computer-assisted identification system is currently available to the USAF and has been proven to work.

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Development and implementation of such a system must be initiated at once if the USAF is to fulfill its responsibility of rapid and scientific, positive identification of the remains of deceased active duty USAF personnel.

BIBLIOGRAPHY

A. REFERENCES CITED

Books

1. Science of Fingerprints. Federal Bureau of Investigation Pamphlet, Washington D.C.: U.S. Department of Justice, 1984.

2. Morse, Dan, Ducan, Jack, and Stoutamire, James. Handbook of Forensic Archaeology and Anthropology. Florida State University Foundation, Inc., 1984.

3. Fisher, Russell and Spitz, Werner. Medicologal Investigation of Death. Springfield, IL: Charles C. Thomas, 1973.

Articles and Periodicals

4. Brannon, Lawrence S., Capt, USA. "Forensic Odontology: An Application for the Army Dentist." Military Medicine, Vol. 148 (Aug 1983), pp. 655-659.

5. Cary, Peter. "The high cost of the FBI's high-tech crime wars." U.S. News and World Report, 30 November 1987, pp. 22-23.

6. "CPU Nabs Suspect." Datamation, November 1, 1983, pp. 66-68.

7. Fiens, Marcella F. and Bishop, Demery R. "New hope for identifying the unidentified." The American Journal of Forensic Medicine and Pathology, Vol. 5, No. 4 (December 1984), pp. 349-371.

8. Fishman, Stuart L. "The use of medical and dental radiographs in identification." International Dental Journal, Vol. 35, No. 4 (December 1985), pp. 301-306.

9. Fulghum, David. "Pathologist Describes Air Crash Aftermath." Air Force Times, 9 June 1986, pp. 18-19, 22.

10. "Future Flight Physicals to Include Footprinting." Air Force Times, 12 Sep 1959, p. 4.

11. Jerman, Albert C., Col, USAF. "Military Requirements for Dental Identification of Human Remains." Military Medicine, Vol. 146 (April 1981), pp. 262-264.

12. Kim, Ho Wohn. "The Role of Forensic Odontology in the Field of Human Identification." International Journal of Comparative and Applied Criminal Justice, Vol. 10, No. 2 (Winter 1986), pp. 243-248.

13. Lambourne, G.T.C. "The Use of Fingerprints in Identification." Medicine, Science and The Law, Vol 19, No. 4 (October 1979), pp. 217-224.

14. Lorton, Lewis and Langley, William H. "Decision-Making Concepts in Postmortem Identification." Journal of Forensic Sciences, Vol. 31, No. 1 (January 1986), pp. 190-196.

15. ----- "Design and Use of a Computer-Assisted Postmortem Identification System." Journal of Forensic Sciences, Vol. 31, No. 3 (July 1986), pp. 972-981.

16. Lire, J.H., et al. "Fingerprint Comparison II: On the Development of a Single Fingerprint Filing and Searching System." Journal of Forensic Sciences, Vol. 27, No. 2 (April 1982), pp. 305-317.

17. Maatz, Larry. "Computer Turns Up Its First Suspect." San Francisco Examiner, 3 March 1984.

18. Neudorfer, Charles D. "Fingerprint Automation: Progress in the FBI's Identification Division." FBI Law Enforcement Bulletin, March 1986, pp. 2-8.

19. Rawson, Raymond D., et al. "Statistical Evidence for the Individuality of the Human Dentition." Journal of Forensic Sciences, Vol. 29, No. 1 (January 1984), pp. 245-253.

20. Smith, Paul. "Army to Test Computerized Dental ID System." Air Force Times, Vol. 45 (8 July 1985), pp. 19-22.

21. "Taking a Byte out of Crime." Time, 14 October 1985, pp. 96-97.

22. "Use of Forensic Denistry Topic of Special Course." Air Force Times, 20 September 1962, p. 37.

23. Vale, Gerald L. "Overview of Forensic Dentistry." Unpub-
lished paper presented at the Forensic Dentistry Con-
ference, Armed Forces Institute of Pathology, 15-19
October 1984.

24. Young, Sharon B. "Panel Faults Army Lab's MIA Identifica-
tion Methods." Air Force Times, 3 March 1986, pp. 2,
30.

25. ----- "Remains Misidentified, Lab Ex-Employee Claims."
Air Force Times, 22 Sep 1986, p. 12.

Official Documents

26. Department of the Army Technical Manual TM 10-286, Identi-
fication of Deceased Personnel, January 1964.

27. USAF Regulation 160-43, Medical Examinations, Atch 3,
Periodic Medical Examination and Scope.

28. USAF Regulation 143-1, Mortuary Affairs, 29 October 1986.

29. USAF Regulation 205-32, USAF Personnel Security Program,
26 June 1987.

30. USAF Regulation 160-17, Physical Examination Techniques,
22 July 1983.

Unpublished Materials

31. Morlang, William M., Col, USAF. "Mass Disaster Manage-
ment." Unpublished paper, pp. 1-19.

Other Sources

32. Darby, Mary L., Henzel, Peter F., and Taylor, Timothy L.
"Washington State: Missing and Unidentified Persons
Computerized System." Presented at meeting of American
Academy of Forensic Scientists, November 1985.

33. De La Rue Printrak Automated Fingerprint Identification
System Catalogue. Anahiem, CA: De La Rue Printrak,
Inc.

34. Lorton, Lewis, et al. "Effects of Computer Use on Mass
        Disaster Identification." Presented at the 39th
        American Academy of Forensic Sciences Conference, 16-21
        February 1987.

35. Mertz, Curtis A. and Purtelo, James M. "Single Computer
        Program for Mass Accident Identification." Presented
        at meeting of American Academy of Forensic Scientists,
        November 1985.

36. NEC Automated Fingerprint Identification System Brochure,
        Washington, D.C.: NEC Information Systems, Inc.

37. Nester, Leonard. Chief, Air Force Mortuary Services,
        Tyndall Air Force Base, Florida. Telecon, 11 December
        1987.